
U. S. DEPARTMENT OF AGRICULTURE,
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DEVELOPMENT OF METHODS OF DRAIN-
ING IRRIGATED LANDS.

By

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DEVELOPMENT OF METHODS OF DRAINING IRRIGATED LANDS.

By C. G. ELLIOTT, *Chief of Drainage Investigations.*

INTRODUCTION.

The necessity of draining irrigated lands in the arid sections has become apparent to those who have been intimately associated with their reclamation and subsequent management. The subject has a peculiar significance to the owners of lands which have succumbed to the inroads of seepage, as excessive moisture is usually called, many acres of which have been abandoned by the owners and are no longer classed as productive property. The fact that large areas of excellent farming and high-priced fruit land have been ruined or seriously injured in each of the States where irrigation is practiced furnishes a sufficient reason for making a careful examination of the methods which have been developed through the efforts of engineers and experts of this office for preventing the extension of such injury in localities where evidences of it appear and of restoring such lands to a productive condition. (Pl. XXIII, fig. 1.) One of the serious and distressing features associated with seeped irrigated land is that a highly productive and prosperous ranch may often be found adjoining another which has been seriously injured or wholly ruined by seepage, both having been reclaimed at the same cost and which were originally equal in productive value. The oft-repeated statement that the condition of the latter is due to careless or unskillful management on the part of the owner is not usually sustained by the facts in the case. The seepage of land is more often due to natural conditions which exist beneath the surface, the effect of which can not be anticipated, than to any indications which are visible at the time the land is first watered. Hence the keen disappointment which the owner feels when seepage and, in some cases, alkali attacks portions of his ranch, and it is not surprising that he casts about for some remedy or possibly abandons the field to salt-grass pasture, alkali bog, or, in the later stages of saturation, to the tule swamp. The hardship which such conditions work upon the less fortunate owner is easy to see, and suggests the thought that there is a certain community of interest among owners of irrigated farms which should

not be disregarded when it is found necessary to undertake drainage operations.

A clear account of methods of draining which are applicable to such cases really involves a description of the surface and particularly the physical features of irrigated tracts in widely separated localities where special methods of draining have been employed, not omitting the difficulties which present themselves when such reclamation is attempted.

To those who are accustomed to draining lands in the humid sections the arid soils present some striking differences in structure and in the manner in which they become wet, as well as in the effect which continued saturation produces on vegetation. Arid soils are usually a mass somewhat uniform in character and without subsoil, as we understand the term in humid sections. With the exception of the adobe class they contain but little clay, but are made up of disintegrated rocks, or in some localities of volcanic ash, sometimes interspersed with gravel, which changes their density and physical condition. They are not laminated or stratified, as are those in the rainfall regions, so we often find them fairly uniform in structure and fertile to considerable depths. The presence of hardpan interspersed at irregular intervals in some localities breaks up this homogeneous character, and, where found, is an important modifying factor in both irrigating and draining. While these are the general characteristics which distinguish them from soils in the rainfall belt, there are any number of differences peculiar to arid soils which give nearly as great a variety of conditions as we find in the humid areas.

CAUSES WHICH PRODUCE SEEPAGE.

The cause of seeped or oversaturated land is the waste from irrigation and leakage from canals and laterals. The skillful irrigator may insist that if no more water is applied than is needed for growing and maturing the crops, and that if the canals are so constructed that no substantial amount of water escapes into the earth, no land will become too wet for farming purposes. It is true that in many instances irrigators have been unduly prodigal in the use of water, particularly when the land is first subdued and watered. The art of economical irrigation is usually learned only when scarcity of water compels its less lavish use. In any event, under methods that we may expect will prevail, some waste of water will occur under the best of management, making draining in many places essential to profitable farming. For these reasons an account of drainage conditions in different localities and the methods of treating them, together with the results which have followed various drainage operations, will be of interest to the holders of irrigated farm lands.

It should be observed as a general truth that water which produces permanent saturation rises from the bottom of the saturated portion toward the surface. Waste from irrigation first passes downward until a hard stratum of earth is reached. This may be only a few feet, in which case the additions which accrue from the irrigation of a few years will bring the permanent ground water level to within 2 or 3 feet of the surface, at which time injury to farm crops will ensue. The distance to a horizon of hard material may be much greater and the intervening ground may permit free percolation, in which case a much longer time will be required to fill the soil, because of the larger reservoir capacity and the relief afforded by underdrainage. It is not the downward movement of water alone which occasions boggy or wet areas, but the lateral movement of ground water down a slope until a flat tract or surface depression checks the flow and causes an accumulation of water, which is made known by its appearance, not, however, until the lower parts of the soil have been filled. Such depressions or level areas receive the accumulated waste water proceeding from adjoining lands, which occupy a higher level. It will be seen that the saturated condition of the land which shows injury is not due to the water which is applied directly to irrigate it, but to the surplus which percolates from the higher lands, sometimes through considerable distances, until it reaches the lower flat or depression.

Drainage has been carried on in the West to such an extent that certain methods are now practiced with reasonable assurance of success. Reference to some of these will indicate the variety of procedure which is now followed, as well as the constructive difficulties which attend this class of improvements. The development along this line which has taken place during the last five years is most encouraging to holders of seeped land.

METHODS OF DRAINING IN THE BEAR RIVER VALLEY, UTAH.

The Bear River Valley in Boxelder County, Utah, is well irrigated and fertile and is occupied by careful farmers who grow sugar beets for the large factory located at Garland, as well as grains and alfalfa, all of which are profitable crops. The soil is a dark loam with a subsoil containing more clay than is usually found in the arid sections. Since 1906 the rise of soil water in many of the fields has been preceded by the appearance of alkali on the surface, which has killed vegetation. So serious did this condition become that some farmers were considering the abandonment of their lands. The successful drainage of a 40-acre field under the direction of this department showed the practicability of preventing the extension of the evil and of restoring the lands to productivity by draining. The

stable condition of the soil, so strikingly and favorably different from the larger part of seeped-irrigated soils, makes the process comparatively simple. It is, in fact, an ideal locality for using drain tile, because a firm bed upon which to place them can be secured, and the earth is sufficiently dense to prevent troublesome washing of the soil into the drains when the fields are irrigated.

It is found here as elsewhere that the location and the depth of drains are two essentials which must be observed in draining. As previously mentioned, alkali and seepage appear upon levels at the foot of slopes or where natural percolation is checked by a reef in the soil. A survey of the subsoil by means of borings is more essential as a preliminary to the construction of drains than is a surface survey. The ground water coming from the lower depths, and being under a pressure or head which tends to force it to the surface, similar to the conditions which produce artesian wells, presents a condition which requires the drains to be placed where the water enters the land, as nearly as possible, thus cutting off the source of the saturation. The ditches for that reason must be deep, 5 feet or more being found necessary for the most effective work. A few lines of tile drains, if properly located and constructed, will frequently effectually dry a large field, whereas, if improperly located and laid at a shallow depth, any number of lines will produce little benefit. Since the time when the practicability of draining the lands in this valley was shown, a drain-tile factory has been established about 5 miles from Tremonton, where a fairly good clay for this purpose is found. This factory is operated by the Acme Clay Co., which is made up of enterprising farmers, such a factory being found necessary because of the lack of drain tile within a convenient shipping distance. The factory (Pl. XXIII, fig. 2) consists of a steam tile mill, one kiln, and some drying sheds. Clay is taken direct from the bank in cars which are drawn up an incline to a dumping platform, where the clay is shoveled by hand labor into the mill which molds the tiles. The freshly molded tiles are dried in the sheds which adjoin the mill and are then placed in the kiln and burned. The ware which is produced is red in color and hard, the latter quality being essential to a permanent drain in alkaline water-logged soils.

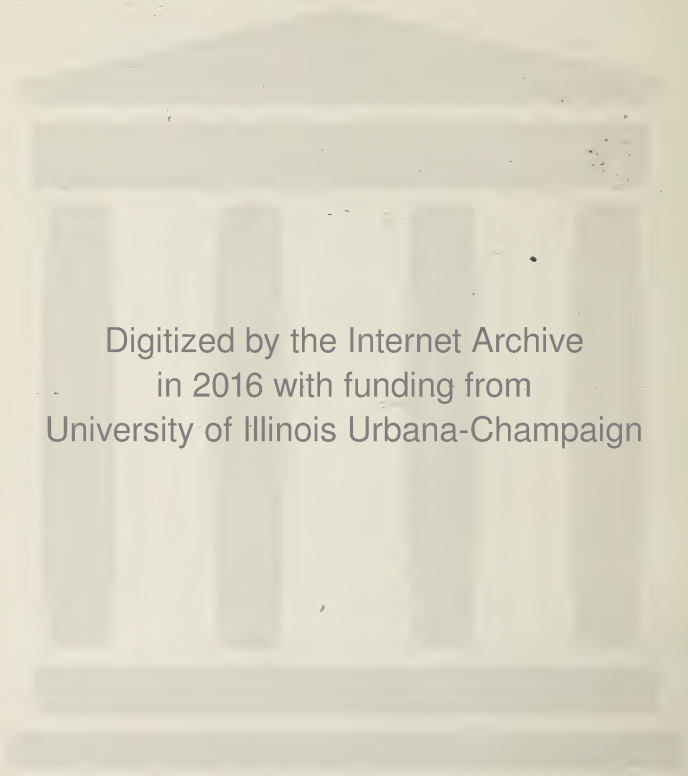
Hand labor is being displaced by steam trenching machines (Pl. XXIV, fig. 1), which work admirably in those soils. They excavate the trench to the full depth required at one passage, delivering the earth on one side convenient for back filling. A grading device permits the operator to control the machine and make the bottom of the ditch conform to the grade which has been previously established by a survey, without which precaution the construction of drains should not be attempted. These lands are more easily drained than are those in many other localities, and, furthermore, the salts which



FIG. 1.—EFFECT OF SEEPAGE AND ALKALI UPON A BEARING ORCHARD IN THE YAKIMA VALLEY, WASH.



FIG. 2.—COUNTRY DRAIN-TILE FACTORY IN THE BEAR RIVER VALLEY, UTAH.



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FIG. 1.—TRENCHING FOR TILE DRAINS BY STEAM POWER, BOX ELDER COUNTY, UTAH.



FIG. 2.—DIFFICULTIES OF CONSTRUCTING DRAINS BY HAND LABOR, MONTROSE, COLO.

destroy the crop as seepage appears are largely sodium chlorid, or common salt, and disappear quite quickly without special treatment after the fields have been drained. The successful introduction of drainage in Boxelder County has relieved the farmers of a menace which threatened the prosperity of the entire region. Since drain tile can be manufactured in the locality and trenching can be done by steam power, the serious obstacle which stood between the farmers and permanent prosperity has been removed.

PROGRESS AND DIFFICULTIES IN WESTERN COLORADO.

The difficulties to be met in draining lands in the Uncompahgre and Grand River Valleys in western Colorado are quite different and more serious. The land is of a shale formation, which when wet becomes exceedingly soft, sometimes to a depth of 10 or 15 feet. The cultivated areas are frequently bordered on one or more sides by lands in which the shale is partially disintegrated and which convey the water from the higher irrigated land, or possibly from irrigating ditches, into the "soil blanket," where it fills up the land so completely as to make a permanent bog. As a preliminary to draining such land soundings or borings are made to locate the position of the shale through which the water reaches the bog. Not infrequently it is entirely impracticable to place a drain through the wet part of the field because of its extremely soft and unstable condition. At least a part of the water must be intercepted and prevented from entering the field before complete drainage can be effected. This is accomplished by placing a drain on the edge of the wet tract in such a way as to penetrate the shale which delivers the water. When such a drain is constructed small streams of water which pour through the crevices of the shale, usually quite strongly impregnated with alkali, will be encountered. Where shale is found it furnishes a firm bed for the drain. Where, however, it is not found within the limits of the depth at which the drain is placed, it is frequently necessary to use a board or prepared frame in the bottom of the trench upon which to lay the pipes, and in addition to this to use gravel to prevent the wet material, which has almost the consistency of water, from entering and filling the drains. After the border drain has operated for a time, by diverting the water from the field, another drain may be laid through the lowest and wettest part of the field, the latter being usually necessary to take care of the surplus water, which is later applied in irrigating. In many instances the intercepting drain will effectually dry the land, but the lower soil having been completely filled with water by the process before described, some permanent drains must be provided to take the waste which will accrue from subsequent irrigation.

The difficulties of construction are often serious and perplexing (Pl. XXIV, fig. 2). The sides of the trench must often be sheathed closely to prevent the earth from caving and filling the trench before the tiles or wooden boxes, which are also used, can be placed in position.

COLLECTING PITS AND SAND TRAPS.

Sometimes it is not practicable to place the tile deep enough to collect the water which presses up from below, in which case pits are excavated 4 feet or more deep directly beneath the drain and are filled with gravel before the tiles are laid (fig. 6). These collect the water which rises and passes off through the drain and are found to be a valuable supplement to the ordinary tile or box drain.

Where a steam-trenching machine is used some device for sustaining the unstable earth until the tile can be laid must be employed (Pl. XXV, fig. 1). An outfit of broad-faced wheels, or in some cases a caterpillar type of truck, must be used to sustain the ma-

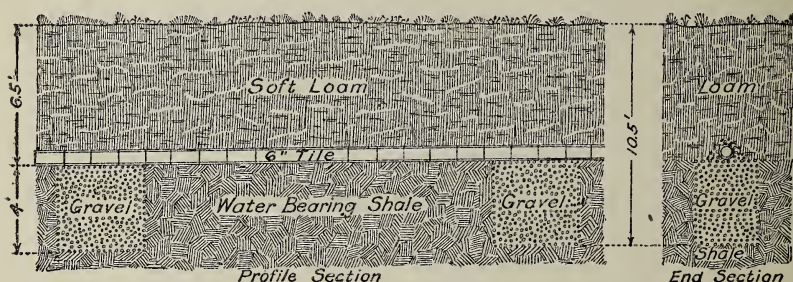


FIG. 6.—Collecting pits in connection with tile drains as used in Montrose County, Colo.

chine as it passes over the soft ground. It has also been found necessary in some localities to attach shields to the excavating wheel and a shield for the shoe to hold the trench open until the tile can be placed in position. This improvement is used at Montrose, Colo., and at Roswell, N. Mex. It is needless to say that draining under such difficulties is at best expensive, yet when we remember that one or two well-located and constructed drains will often dry an entire field of considerable size, the cost per acre is quite reasonable.

Sand traps or silt wells are a necessary adjunct to nearly all lines of tile drains, and should be placed at junctions with other lines and at convenient points along each drain. Their office is to cause the sand which is carried by the drain to deposit itself in the well, from which it can be removed when necessary. They are box wells, 3 by 3 feet in section, extending from a point 2 feet below the drains to the surface of the ground. The drains discharge into the well, dropping the sand which was held in suspension, the water passing out through the drain on the opposite side.

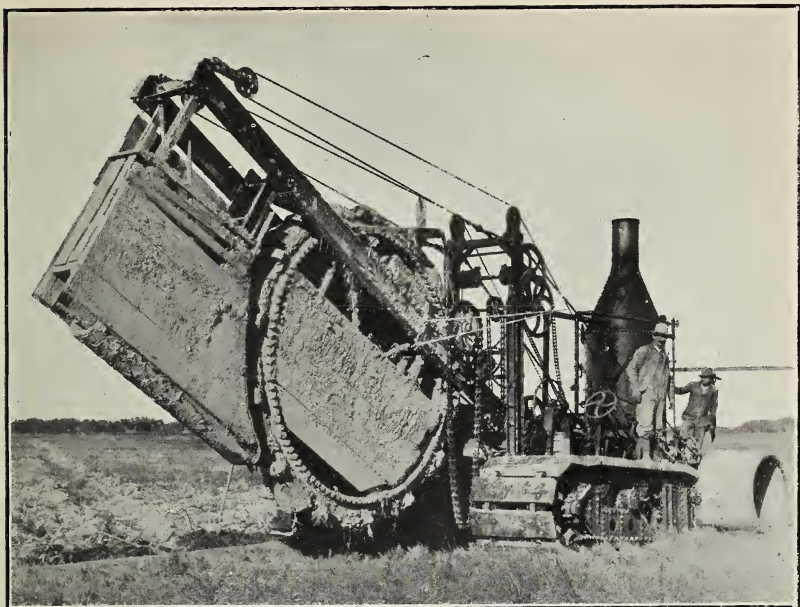


FIG. 1.—STEAM TRENCHING MACHINE EQUIPPED FOR SOFT LAND, ROSWELL, N. MEX.



FIG. 2.—DITCHING WITH A STEAM LAND DREDGE, MOXEE VALLEY, WASH.

SPECIAL RELIEF WELLS AND DISCHARGE DRAINS.

Reference has been made to the utility of "relief wells," as they are commonly called, for reaching and removing water which lies deeper than it is practicable to construct drains. This system is employed with most gratifying effectiveness where a gravelly soil disappears beneath a blanket of loam. The gravel permits a relatively free flow of waste water into the loam soil lying upon a lower level, where it remains to fill up the soil and produce a boggy condition. Relief-well drainage consists in sinking wells of greater or less diameter into the water-bearing gravel, which is found on the

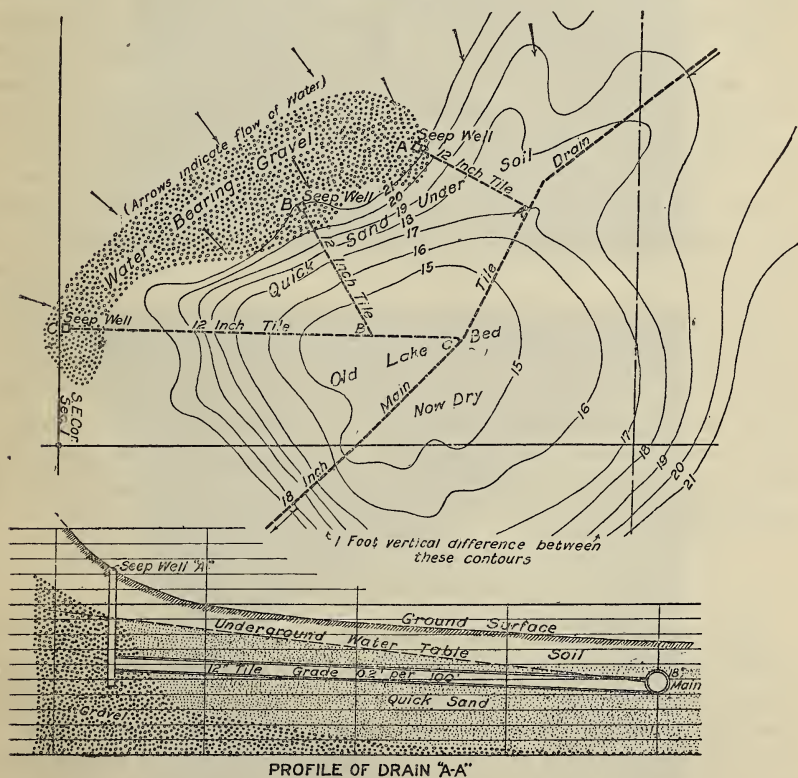


FIG. 7.—Plan and profile showing relief drainage wells as used in Otero County, Colo.

outer edge of the loam area at points where the gravel ceases or dips under the blanket of loam. Large tile drains are then laid at a convenient depth to connect the wells with a watercourse or large ditch. This plan of drainage has been used by Mr. Albert R. Beymer on the lands of the American Sugar Beet Co., in Otero County, Colo., with remarkable success wherever gravel can be located. The method was first recommended in 1902 by the writer, and has been found successful in other localities wherever the conditions are favorable. Figure 7 represents the conditions under which

the plan operates successfully. The wells are usually not less than 9 feet deep and 3 by 4 feet in section, commonly curbed by plank, and the outlet drains are laid about 4 feet deep, in the manner shown in the figure. Three or four wells with their respective outlets will sometimes drain 100 acres in localities where any number of tile drains laid through the wet land in the ordinary way would prove ineffective.

STEAM LAND DREDGES.

The methods so far described are those which pertain to drying the field. Covered drains are always preferable except where the volume of water becomes so great that they can not be used on account of the cost. Open ditches must then be constructed where outlets for large areas are required. The construction of such ditches through land which has become seeped and soft is often attended with considerable difficulty, as well as is their maintenance after construction. The steam land dredge is employed, as other means for excavating the ditches have been found impracticable where the ground has become saturated to a considerable depth. The difficulty of excavating such ditches emphasizes the wisdom of constructing the necessary drains as soon as the need of them appears. A drag-line bucket dredge which moves ahead of the excavated ditch is well adapted to the work. (Pl. XXV, fig. 2.) The platform upon which the machine is mounted is moved on rollers or on skids ahead of the ditch as it is excavated. Ditches about 8 feet deep, and located so that all drains within the area to be restored can be discharged into them, are a necessary part of the reclamation of any large area of seeped lands. (Pl. XXVI.)

MAINTENANCE.

Constant attention will be required to maintain open ditches in proper condition. They are subject to obstruction by the accumulation of Russian thistles and other weeds which the wind carries into them, and to filling by soil which is washed from the adjoining lands by waste water, when the fields are irrigated. Covered drains must also receive attention in soils which do not become compact and firm over the drain, for the reason that whenever the land is irrigated water will quickly find its way into the drain, carrying with it an amount of soil which will soon fill and obstruct it. This inconvenience and risk disappears as the earth with which the trench is filled becomes compacted, which condition is hastened if special care is taken in packing the earth at the time the trench is filled. Attention to the many details of construction and maintenance which can not be enumerated here are required in draining irrigated fields.



FIG. 1.—A DRAINAGE DITCH MADE WITH A STEAM DREDGE IN THE YAKIMA VALLEY, WASH.



FIG. 2.—HAND-EXCAVATED DRAINAGE DITCH CURBED TO PREVENT CAVING, SUNNYSIDE, WASH.



CEMENT DRAIN TILE.

No little discussion has arisen concerning the utility of cement tile for draining seeped lands, especially those which are strongly charged with alkali. The scarcity of well-burned clay tile, as well as of good clay for manufacturing them, in regions where they are most needed, makes it desirable to use cement if it is possible to do so. The experiments made in 1909 by R. A. Hart, drainage engineer of this office, published in the Transactions of the American Society of Engineers,¹ indicate that the presence of salts such as are found in soils hastens the setting of the cement and increases its tensile strength on a 30-day test. Exposure for 28 days in solutions of different kinds of alkali appears to point to the fact that the sulphates attack and destroy the solidity of the sample, while the chlorids and carbonates do not. The evidence furnished by tiles which have been in operation is conflicting, some having remained intact for 10 years and still manifest no sign of disintegration, while others apparently as well made have failed within a year. Those who have experience in the use of this material maintain that if tiles are molded from a mixture of one part good cement and three parts of the aggregate used in a wet state, they will resist injury by alkali. The varieties of alkaline salts which are found in seeped lands is so great, and their possible combinations are so numerous, that the use of cement tile for draining such lands is attended with considerable risk. Experience so far suggests that the pipes should be made dense and practically nonabsorptive if they are to be safely used in water which contains a considerable amount of alkaline salts from the soil. Even clay tiles which are soft or poorly burned should be discarded on the score of probable disintegration if they absorb water freely. What are known as "seconds" at sewer-pipe factories are excellent for draining and are quite commonly employed where tiles of large size are needed.

WOODEN BOX DRAINS.

The subject of material which is used for drains should not be passed without reference to wooden boxes, which, of necessity, are employed in many localities because more lasting material can not be obtained at a reasonable cost. They serve an excellent purpose while they last and have been exceedingly useful in experimental drainage where the doubtful results of the experiment did not seem to warrant the use of more expensive material. They are made in rectangular form, with or without bottoms, according to the ground in which they are to be used. If the bed upon which they are to be laid is hard clay or gravel, no bottoms are needed unless the fall of

¹ Trans. Amer. Soc. Civ. Engin., vol. 67, p. 587.

the drains is considerable. Generally it is necessary to provide bottoms to prevent them from becoming choked with sand or mud. The boards forming the bottoms are separated from the sides by pieces of one-half inch lath, which makes an opening for the entrance of water on each side of the box. All other parts of the box are made tight. So soft is the ground in many cases that it becomes necessary to surround the box with gravel to prevent the entrance of mud through the openings in the boxes, small though they may be. The boxes are made in lengths convenient for use, and vary from 8 feet to 16 feet. Their use should not be discouraged except where the more lasting drain tiles can be obtained at reasonable cost. Lumber is not durable except where it is constantly saturated. This condition exists where some drains are used, but not in others, so that it is wise to secure hard-burned drain tile for this work wherever it is possible to do so. The larger sizes only are required in this kind of work, which fact adds largely to the cost of the drain if the tiles are shipped from a distance, and often induces the drainer to use pipes that are too small.

COOPERATIVE DRAINAGE.

The successful drainage of the field and ranch has developed the necessity of more extended work to secure outlets which are adequate to receive the water from the several farms. Irrigated land has few, if any, watercourses, so that drainage water must be delivered through artificial ditches, usually to the same stream from which the water was originally diverted. The construction of such outlet drains requires the cooperation of the owners of land which is to be benefited. This is secured under the provisions of the State drainage laws, which permit owners of land to form a corporate district and distribute the cost of the work among the several owners in proportion to the benefit each will receive. The assessments so apportioned are collected as taxes and the proceeds applied to pay for the cost of such work as has been agreed upon. Each landowner within the district then has a right to use the outlets and participate in all of the benefits which will accrue from the work.

It is quite often the case that little or no field drainage can be successfully done until outlets have been made. Districts of this character containing 10,000 acres or more have been inaugurated in the States of Washington, Utah, and Colorado, but none has as yet been completed. This feature of drainage, which has but recently been forced upon the people in certain sections, is new and brings up some troublesome questions concerning the location of such drains as will prove of common utility, and also concerning the equitable

assessment of their cost upon the several tracts of land for which they provide drainage.

There are at least 800,000 acres of irrigated land which now require draining in order to make them profitably productive, the larger part of which will require the construction of outlet drains in which more or less cooperation of property owners will be required. After the land which is drained has become fairly free from alkali, with which it is often highly charged, the water flowing from the main drains becomes highly valuable for irrigating. Such water then becomes an asset, since it may be used to irrigate lands occupying a lower level. These questions have not yet been adjusted satisfactorily in connection with drainage projects. In fact, they are only broached when the necessity for public drainage districts requires their consideration. It is quite certain that drainage districts must soon be as much a feature of irrigated farming as they now are of agriculture in the humid sections.

BENEFICIAL EFFECT OF DRAINING ON ALKALI LAND.

One of the effects of over saturation in many localities is the accumulation of harmful salts, commonly called alkali, in the soil. Their appearance, which is manifested by the failure of crops, is frequently the first intimation the farmer has that his land has become too wet. Effective drainage removes the cause of the accumulation, yet special treatment is frequently required to remove the excess of alkali sufficiently for growing crops. Copious irrigation, followed by thorough and deep cultivation and the growing of alkali-resistant crops for a season or two, quite commonly restores the land to its former productive condition. Some fields, however, are so fully charged with salts, due to seepage and to neglect in the use of preventive measures, that a longer treatment by various methods of flooding, in connection with the relief that is furnished by drainage, is required. Complete drainage, however, is the first essential in such reclamation, but should be followed by liberal irrigation until the alkali has been removed sufficiently to permit the soil to grow a crop, after which the quantity of water may be adjusted to the actual needs of the crops which are to be grown. No fact has been more thoroughly developed or forcibly emphasized by drainage experiments and ordinary field practice than the value of timely attention to this subject as a preventive of seeped and boggy fields.

PUMPING DRAINAGE WATER FROM SUMPS INTO IRRIGATION DITCHES.

This method of disposing of drainage water has been found practicable in the Fresno district of California. That great irrigated plain is not traversed by streams which can be conveniently utilized

as drainage outlets. The plan of discharging tile drains into sumps about 10 feet deep, located at a convenient supply lateral or canal, and establishing a small pumping plant at each to lift the water into irrigating canals was proposed by the writer in 1903, and is described in circulars Nos. 50 and 57, and further in Part IX of Bulletin 158 of this office. This method was put in operation experimentally in 1906 and 1907, under the supervision of irrigation investigations of this office, in which the owners of the land upon which the plants were located and the State of California cooperated. The results of this investigation and experiment are set forth in Office of Experiment Stations Bulletin 217. The plan, briefly stated, is to discharge the water from a system of tile drains into a sump or well 9 feet or more deep. A vertical centrifugal pump is placed at the bottom, the shaft extending to the surface, where it is operated by an electric motor connected to the pulley by a belt, a power line through that section making the use of electrical power possible and practicable. The water which is pumped is not sufficiently charged with alkali to unfit it for irrigation, especially when diluted with the water supply of the canal into which it is pumped. As a result of this investigation and trial of the plan originally proposed, which was successful, the method is now used on two fruit ranches where drainage systems and a pumping plant have been installed entirely at the owner's expense, and the land is being effectually reclaimed from the evils of both seepage and alkali. Since this land is 20 miles distant from a gravity outlet, the ability to accomplish drainage in this manner makes it possible for individuals to drain their lands without being dependent upon the organization of a large cooperative outlet scheme, which, however, ought to be worked out whenever it is possible to do so.

It may have occurred to the reader that there are some striking characteristics in the development of drainage methods for irrigated land when compared with ordinary practice in the humid sections. The ineffectiveness of drains which are laid 3 or 4 feet deep has been repeatedly demonstrated. The many failures in the West of methods which are commonly practiced and are successful in the East at one time gave abundant support to the belief often expressed by those who made the attempt that such land could not be drained. Costly experience has fairly well established the fact that 6 feet is about the minimum depth at which drains should be placed under the conditions which usually prevail in irrigated fields. Instances might be mentioned where a series of shallow drains which failed to accomplish the expected result have been replaced by drains 6 and 7 feet deep with satisfactory results. Two reasons for this increased depth may be given. First, if the drains are not deep they will not intercept the underflow, and therefore will have no effect in diminishing the vol-

ume of water which causes saturation; and, second, the capillarity of the soil is such that if the free water of the soil is not kept low, moisture containing alkali will be brought to the surface and the salt deposited when the moisture disappears as vapor. Again, the plan of using a few well-located and deep drains to intercept the underflow before it reaches the land which requires drainage is not commonly employed in regions of plenteous rainfall for the reason that in the latter case drainage consists in removing the surplus water which falls directly upon the field, while in the former it is the removal of the surplus underflow which percolates from an adjoining tract of land.

The method of draining by relief wells, which has been described quite fully and its value emphasized, is but the adaptation of what is known as the Elkington system to the drainage of irrigated lands. The method of tapping underground springs, which cause seeped and boggy lands, by means of wells, was originated by Joseph Elkington, of Warwickshire, England, in 1765, and was introduced in Sweden by George Stephens in 1806, with most excellent results. In 1795 Parliament voted Elkington £1,000 in appreciation of his services in discovering and developing a method of draining which had proven of great value to the Kingdom. In profiting by this discovery, which is so applicable to the betterment of our saturated irrigated lands, it is only fitting that we give Elkington due credit.

The developments of the last few years have forced upon our attention the necessity of draining and at the same time have increased our confidence in the practicability of reclaiming seeped lands and of restoring them to their former productiveness. It is quite clear to the careful observer that the application of the various methods which have been described will soon be extensively practiced in many sections of the irrigated West.



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